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IMPACT ASSESSMENT
Western Spruce Budworm

South Cecilia Timber Sale
Coyote Ranger District
Santa Fe National Forest
New Mexico

May 1984

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USDA Forest Service, Southwestern Region
State and Private Forestry
Forest Pest Management
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ABSTRACT

Western spruce budworm, Choristorneura occidentalis Free., defoliation impacts on mixed conifer stands in the South Cecilia timber sale, Coyote Ranger District, Santa Fe National Forest, were assessed. Damage to Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco, and white fir, Abies concolor (Gord. and Glend.) Lindl., ranged from light defoliation to mortality. Incidence and impacts of other pests were also recorded. Current stand conditions, pest damage prognosis, and management recommendations for each stand are discussed.

INTRODUCTION

Tree damages caused by the western spruce budworm, Choristoneura occidentalis Free., generally can be quantified as various amounts of growth loss, top-kill, seed damages, and mortality in Douglas-fir and white fir stands. The intensity and duration (consecutive years) of defoliation are directly related to the severity of tree damage. Tree mortality generally occurs only after several years of severe defoliation and is usually concentrated in understory and small-size class trees. These damages adversely affect stand values and future stand productivity.

Silvicultural management has been suggested as a method of reducing stand susceptibility and vulnerablity to western spruce budworm damage (Fellin 1976, Carlson et al. 1983, Johnsen 1983). The strategies suggested by Southwestern Region Forest Pest Management involve intermediate and regeneration cutting methods which generally reduce the shade-tolerant true fir component and favor creation of even-aged stands. These silvicultural strategies can be incorporated into specific stand prescriptions and applied during scheduled timber harvest operations. Considering this opportunity, the Coyote Ranger District, Santa Fe National Forest, requested Forest Pest Management to evaluate current damages due to western spruce budworm in Douglas-fir and white fir stands on the South Cecilia timber sale and to provide recommendations to reduce vulnerability to budworm damages in the future. The sale area was evaluated in October and November 1983.

OBJECTIVES

The objectives of this evaluation are:

1. Estimate current stand conditions and pest damage.
2. Provide a pest damage prognosis.
3. Recommend appropriate management alternatives.

SALE AREA

The South Cecilia sale area is located south of Gallina on the Coyote Ranger District (figure 1). White fir and Douglas-fir stands comprise approximately 53 percent of the estimated 3,200 operable acres on the sale. The sale is targeted to produce a net volume of 8.0 MMBF.

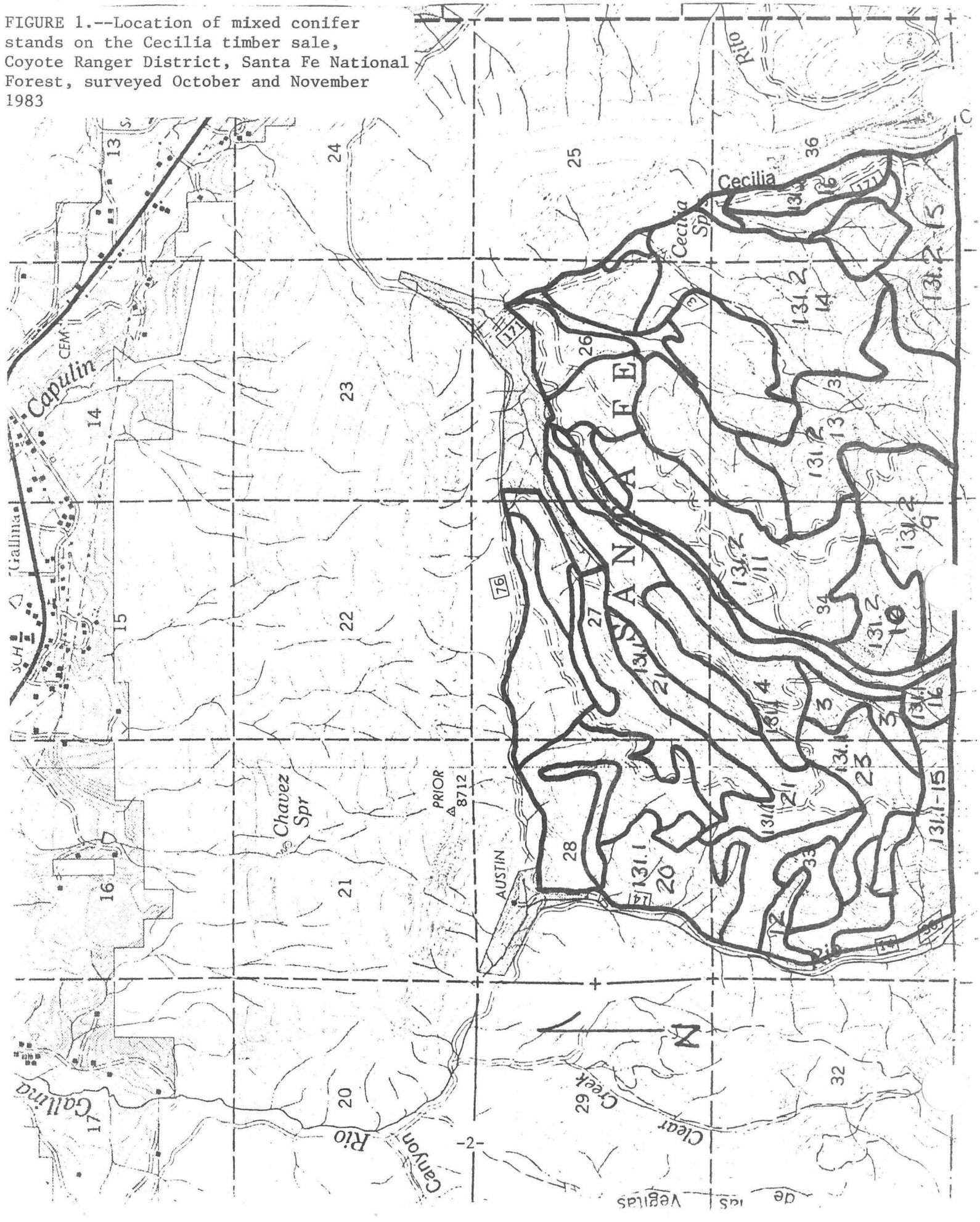

FIGURE 1.--Location of mixed conifer stands on the Cecilia timber sale, Coyote Ranger District, Santa Fe National Forest, surveyed October and November 1983

The western spruce budworm has been at epidemic levels within the sale area since 1978. In 1983, budworm egg mass density was estimated at 29 egg mass per m^2 foliage (Telfer 1984), again at epidemic levels.

METHODS

Individual mixed conifer stands within the sale were surveyed using the INDIDS R03 survey system; see Bennett et al. (1983). Figure 1 shows location of the compartments and stands. Plots were established on either a 5- X 5-, 5- X 10-, or 10- X 10-chain grid pattern, depending upon stand size. A minimum of 10 plots was established in each stand. The average number of plots per stand was 18.

Plots consisted of a 20 BAF variable point sample (10 BAF on several stands) and a 1/300-acre fixed plot. All trees larger than 5 inches in diameter (d.b.h.) were recorded on the variable point samples. All trees taller than 3 inches, but less than 5 inches d.b.h., were recorded on the fixed plots. Tree diameters were measured to the nearest tenth of an inch. Tree heights were measured to the nearest foot on 25 percent of the trees tallied on the variable point samples.

All identifiable pest problems on all tally trees were recorded. Budworm damages were recorded as follows:

0 - No damage

11 - Light defoliation; defoliation of the current year's foliage only.

12 - Moderate defoliation; defoliation on the last 2 years' foliage.

13 - Heavy defoliation; defoliation of three or more years of foliage.

14 - Light top-kill; apparent top-kill of less than 1 foot of the terminal leader on trees greater than 5 inches d.b.h. and less than 0.5 feet of apparent top-kill of the terminal leader on trees less than 5 inches d.b.h.

15 - Moderate top-kill; 1 to 2 feet of apparent top-kill on trees greater than 5 inches d.b.h. and 0.5 to 1.0 feet of apparent top-kill on trees less than 5 inches d.b.h.

16 - Heavy top-kill; more than 2 feet of apparent top-kill on trees greater than 5 inches d.b.h. and more than 1 foot of apparent top-kill on trees less than 5 inches d.b.h.

17 - Budworm-caused mortality.

Some trees classified as light top-kill were probably just heavily defoliated. Trees classified as budworm-caused mortality included trees that have been so severely defoliated that they are expected to succumb within a year or two, regardless of future defoliation. These trees had only several twiglets with live older needles.

Dwarf mistletoe-infected Douglas-fir and ponderosa pine were rated using the 6-class system developed by Hawksworth (1977).

RESULTS

Current stand conditions and pest prognoses for individual stands are included in appendix A. In summary, white fir is the major tree species in all of the mixed conifer stands, particularly in the small-size classes. Douglas-fir and ponderosa pine vary from rare to a major component of the stand. Ponderosa pine regeneration is rare; Douglas-fir regeneration varies. Oak is a substantial component of most stands.

The budworm has caused severe permanent tree damages to the mixed conifer stands and, in particular, to the white fir component. Much of the Douglas-fir and white fir regeneration has been severely damaged. Pole and small sawtimber white fir have been permanently damaged in many stands, which will result in defect and degrade in the future.

Dwarf mistletoe is present on ponderosa pine and Douglas-fir and is quite severe in some stands. Several root rot centers were detected.

Specific data for each stand are on file and available at USDA Forest Service, Forest Pest Management, Albuquerque, New Mexico.

SILVICULTURAL ALTERNATIVES

Discussion of applicable silvicultural alternatives for mixed conifer stands on the South Cecilia timber sale follows:

1. Intermediate Cuts

Intermediate cuts that will salvage tree mortality due to budworm defoliation and regulate stand stocking levels and species composition are desirable. The following methods are suggested.

a. Thinning

A thinning from above can be performed in immature stands with dense overstories and low-level budworm damages. Residual trees should be ponderosa pine and Douglas-fir when possible. Budworm-damaged and diseased trees should be discriminated against. White fir advanced regeneration should be destroyed, where possible. This cut should be performed in stands which are not predominately

white fir and which are not yet severely damaged by the budworm. The resulting stands should be less vulnerable to damages from future budworm outbreaks because of increased tree vigor and a reduced budworm-host tree component.

b. Sanitation/Salvage

In stands that have incurred heavy to severe budworm damage, a sanitation/salvage cut removing all budworm-damaged trees and highly susceptible white fir can be performed. White fir advanced regeneration should be destroyed. Sanitation/salvage is appropriate in both mature and immature stands where budworm damage has made successful regeneration unlikely or expected productivity has been reduced to a point where it is uneconomical to carry a stand to rotation age. In many situations, artifical regeneration of salvaged stands will be necessary.

2. Harvest Cutting-Regeneration Methods

Regeneration cuts are desirable in mature stands which have sustained only light to moderate budworm damages and/or are composed almost exclusively of budworm host-tree species. Even-aged methods which tend to create single-storied stands are preferred. The following regeneration cuts are possible:

a. Shelterwood

The shelterwood regeneration method can be used to create new stands that are primarily composed of tree species that are not preferred budworm hosts. Shelterwood cuts should be used in areas where budworm damage is not yet severe enough to prevent establishing natural regeneration. Seed cuts should first remove undesirable species in all crown classes and should open up the stand sufficiently to promote the less shade-tolerant ponderosa pine and Douglas-fir regeneration over white fir regeneration. White fir regeneration should be discriminated against during final removal cuts and future thinnings.

b. Simulated Shelterwood

The simulated shelterwood regeneration method is appropriate in stands which have advanced regeneration of ponderosa pine, Douglas-fir, and other budworm nonhost tree species that have not been damaged by the budworm. Since advanced regeneration is the first to be damaged by the budworm, this method will be applicable in stands which generally have had budworm infestations for 3 years or less.

c. Seed Tree

Seed-tree cuts are appropriate for stands that have sufficient numbers of ponderosa pine and/or Douglas-fir trees suitable

for use as seed trees. All other trees, merchantable and nonmerchantable, must be removed. Considerable site preparation will be necessary in most stands due to the prevalence of oak brush that exists throughout much of the sale area. Douglas-fir seed trees may not produce a good seed crop until the budworm outbreak collapses.

Seed trees should not be severely dwarf mistletoe-infected; however, if mistletoe-infected trees must be used, the trees should have a dwarf mistletoe rating of less than 3 and should be removed as soon as regeneration is established or no more than 10 years after the cut.

d. Clearcut

Clearcuts are appropriate for stands that have sustained heavy budworm damages or have an insufficient number of desirable trees species for successful regeneration using either the shelterwood or seed-tree methods. All trees, merchantable and nonmerchantable, must be removed. Again, considerable site preparation will be necessary in most stands due to the prevalence of oak brush. Artifical regeneration of ponderosa pine and/or Douglas-fir will be necessary.

Stands resulting from these regeneration cuts should primarily consist of ponderosa pine and Douglas-fir. During future stand entries, any white fir natural regeneration should be discriminated against.

RECOMMENDATIONS

For most of these mixed conifer stands where white fir is the predominant tree species and permanent budworm-caused damages have occurred, we recommend sanitation/salvage, with artificial regeneration with ponderosa pine and Douglas-fir. In stands which have not been severely damaged by the budworm, we recommend any of the even-aged regeneration methods previously discussed. These cuts will maximize utilization of the current stands and should reduce vulnerability to future budworm outbreaks by creating thrifty vigorous stands with few budworm host-tree species present.

The other cuts are presented, with probable budworm impact described, for stands where other management objectives, such as wildlife, visual quality, etc., prevent the use of sanitation/salvage or clearcuts.

Budworm host-tree species, particularly white fir, that are present in stands typed as ponderosa pine should be discriminated against in the current timber sale and in all future stand entries.

Current stand conditions, pest damage prognosis, and recommendations for each stand surveyed are presented in appendix A.

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APPENDIX A

Current Stand Conditions, Pest Damage Prognosis, and Recommendations for Each Specific Mixed Conifer Stand

Current Conditions

The stand is on a rocky, steep ridgetop.

Douglas-fir is a major component of the stand; 24 percent of the trees and 29 percent of the basal area. Budworm damages are at moderate levels. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	13	75	0
Poles (5-8.9")	16	84	0
Small sawtimber (9-11.9")	40	45	0
Sawtimber (12"+)	42	58	0

No mortality has occurred yet, but seedling and sapling mortality can be expected to start within 2 to 3 years. A majority of trees 9 inches and larger already have top-kill. Dwarf mistletoe is present on 38 percent of the seedlings and saplings and 30 percent of the sawtimber.

White fir is the predominate tree species; 55 percent of the trees and 54 percent of the basal area. Seedlings and saplings are 77 percent of the trees. Budworm damages on white fir are severe. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	6	67	11
Poles (5-8.9")	39	55	6
Small sawtimber (9-11.9")	42	58	0
Sawtimber (12"+)	61	26	0

Damages are most severe on the small-size classes. Pole-size mortality and small sawtimber top-kill are prevalent in dense white fir groups. Since top-kill causes significant defect, these trees are valueless for the next stand. Fir broom rust is present, but rare.

Other species include: Aspen, 2 percent of the trees and 5 percent of the basal area; blackjack pine, 3 percent of the trees and 1 percent of the basal area; yellow pine, less than 1 percent of the trees and 6 percent of the basal area; and oak, 16 percent of the trees and 5 percent of the basal area.

There are no significant pest problems on these species.

Prognosis

Budworm damages are already severe. Percentage of trees with top-kill and mortality will increase within each size class.

Recommendations

There are sufficient numbers of Douglas-fir, white fir, and ponderosa pine advanced regeneration; however, budworm damages on the Douglas-fir and white fir are already so severe as to render the trees useless. Thus, we recommend sanitation/salvage, with artifical regeneration of ponderosa pine and/or Douglas-fir.

STAND 131.1-4

Current Conditions

Douglas-fir is a minor component; 4 percent of the trees and 1 percent of the basal area. The majority, 99 percent, of Douglas-fir is regeneration. Of this regeneration, 75 percent has suffered either top-kill or mortality.

White fir is the major tree species; 51 percent of the trees and 57 percent of the basal area. Over 80 percent of the white fir is regeneration. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	59	20	11
Poles (5-8.9")	47	36	14
Small sawtimber (9-11.9")	31	59	11
Sawtimber (12"+)	37	63	0

Budworm damages are severe on white fir; mortality is occurring on seedlings up to small sawtimber. This is a result of dense groups of white fir with several crown layers. A suspected root rot center was detected.

Other tree species include: Aspen, 7 percent of the trees and 2 percent of the basal area; blackjack pine, 14 percent of the trees and 22 of the basal area; yellow pine, less than 1 percent of the trees and 11 percent of the basal area; and oak, 23 percent of the trees and 6 percent of the basal area.

Dwarf mistletoe is present on 40 percent of the blackjack pine, with 45 percent of the pine regeneration infected.

Prognosis

Budworm damages are already severe and will increase over the next several years. The advanced regeneration is already damaged sufficiently so as to be worthless. The majority of poles and small sawtimber will be of low value, since the top-kill will cause defect and degrade in the future. Dwarf mistletoe infections will increase in severity.

Recommendations

Since budworm damages are already severe, particularly on the advanced regeneration, two alternatives are proposed. Where there is sufficient seed-tree quality pine at the proper spacing, a seed-tree cut, leaving ponderosa pine, is recommended. Where there is no pine, or the pine is infected with dwarf mistletoe, sanitation/salvage, with artifical regeneration of pine and/or Douglas-fir, is recommended.

STAND 131.1-12

Current Conditions

Douglas-fir is only 6 percent of the trees and 14 percent of the basal area. The majority of the Douglas-fir are seedlings and saplings. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	50	50	0
Poles (5.0-8.9")	52	13	0
Small sawtimber (9-11.9")	100	0	0
Sawtimber (12"+)	33	0	0

Dwarf mistletoe was recorded on one sawtimber tree.

White fir is the major tree species; 57 percent of the trees and 64 percent of the basal area. If oak is excluded, white fir is 82 percent of the trees. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	12	24	52
Poles (5-8.9")	83	15	0
Small sawtimber (9.11.9")	93	6	0
Sawtimber (12"+)	79	20	0

As expected, budworm damages are more severe on small-size classes. Fir broom rust is present on 5 percent of the trees 5 inches in diameter and larger.

Other species include: Blackjack pine, 3 percent of the trees and 8 percent of the basal area; yellow pine, less than 1 percent of the trees and 7 percent of the basal area; Engelmann spruce, 2 percent of the trees and basal area; juniper, 2 percent of the trees and 1 percent of the basal area; and oak, 31 percent of the trees and 4 percent of the basal area.

There are no significant pest problems on these species.

Prognosis

The stand is susceptible to budworm damages, since the primary tree species is white fir. Top-kill and mortality of the smaller size classes will increase with several more years of outbreak level budworm populations. These trees, both white fir and Douglas-fir, will not be suitable for the next stand. Top-kill and the resulting deformity and degrade will increase on the poles and small sawtimber white fir in the next several years, particularly on the less vigorous lower crown class trees.

Recommendations

Sanitation/salvage, with artifical regeneration of ponderosa pine and/or Douglas-fir, is recommended, since advanced regeneration is predominately budworm-damaged white fir. Treatment of the oak brush will be necessary to have successful regeneration.

STANDS 131.1-15 AND 131.1-16

Because of their similar characteristics, stands 131.1-15 and 131.1-16 were combined.

Current Conditions

These stands are white fir along the creek, extremely open with oak brush on the midslope, and residual open-grown yellow pine with white fir underneath on the ridgetop. Stocking levels are variable.

Douglas-fir is the second most common commercial tree species; 16 percent of the trees and 24 percent of the basal area. The majority, 75 percent, of the Douglas-fir trees are seedlings and saplings. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	44	22	11
Poles (5-8.9")	44	14	16
Small sawtimber (9-11.9")	72	0	0
Sawtimber (12"+)	68	5	0

Budworm damages and dwarf mistletoe infections (DMR >4) are severe. Percentage of the trees with dwarf mistletoe, by diameter class, is: Seedling and saplings (0-4.9"), 33 percent; poles (5-8.9"), 42 percent; small sawtimber (9-11.9"), 83 percent.

White fir is the predominate tree species; 48 percent of the trees and 51 percent of the basal area. The majority, 74 percent, of white fir trees are seedlings and saplings. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	46	19	8
Poles (5-8.9")	66	30	4
Small sawtimber (9-11.9")	77	24	0
Sawtimber (12"+)	90	10	0

Budworm damages are more severe on the white fir than the Douglas-fir, but are not as severe as in some other stands. Fir broom rust is present; 16 percent of the trees, excluding seedlings and saplings, are infected.

Other tree species include: Aspen, 6 percent of the trees and 4 percent of the basal area; blackjack pine, 1 percent of the trees and 11 percent of the basal area; yellow pine, less than 1 percent of the trees and 6 percent of the basal area; Engelmann spruce, 1 percent of the trees and basal area; juniper, less than 1 percent of the trees and basal area; and oak, 26 percent of the trees and 3 percent of the basal area.

Stem decay is common on small sawtimber and sawtimber aspen; 53 percent of the trees are infected. Dwarf mistletoe is present on blackjack and yellow pine, but at low levels, 2 and 7 percent, respectively.

Prognosis

Permanent budworm damages, top-kill and mortality, will increase on both Douglas-fir and white fir in the next several years. The seedlings and saplings, especially Douglas-fir, are already sufficiently damaged so as to prevent their use for the next stand. Dwarf mistletoe will increase in severity on the Douglas-fir.

Recommendations

The recommendations are split within the stand. On the ridgetop, sanitation/salvage, with artifical regeneration of ponderosa pine and Douglas-fir, is recommended. There is insufficient ponderosa pine to do a seed cut, the white fir is damaged enough to prevent use in the next stand, and the Douglas-fir is heavily infected with dwarf mistletoe. The midslope is steep and covered with oak. No management is the recommendation for this area due to the steep slope and difficulty in establishing seedlings on dry oak-covered slopes. For the bottom of the slope, a seed-tree cut, with spruce and Douglas-fir as first choices for seed trees, is recommended.

Current Conditions

Douglas-fir is a significant component of the stand; 12 percent of the trees and 20 percent of the basal area. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	55	9	0
Poles (5-8.9")	91	5	0
Small sawtimber (9-11.9")	100	0	0
Sawtimber (12"+)	88	0	0

Although budworm-caused defoliation was common throughout the Douglas-fir, not much permanent damage has occurred. Dwarf mistletoe infections are rare.

White fir is the major tree species; 35 percent of the trees and 38 percent of the basal area. If oak is excluded, white fir is 56 percent of the trees. Budworm-caused defoliation is extremely high in all size classes; however, very little permanent damage has occurred thus far. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	86	3	0
Poles (5-8.9")	100	0	0
Small sawtimber (9-11.9")	96	0	0
Sawtimber (12"+)	94	0	0

Root diseases and butt/stem decay are present, but in insignificant amounts (less than 1 percent of the trees and 2 percent of the basal area). Occasional white fir mortality was observed, but cause of death could not be determined. No evidence of Armillariella mellea was found.

Other species included: Aspen, less than 1 percent of the trees and 1 percent of the basal area; blackjack pine, 6 percent of the trees and 34 percent of the basal area; yellow pine, less than 1 percent of the trees and 4 percent of the basal area; Engelmann spruce, 2 percent of the trees representing no basal area; and oak, 44 percent of the trees (all less than 5 inches d.b.h.), representing only 1 percent of the basal area.

Dwarf mistletoe was present in 13 percent of the blackjack and 8 percent of the yellow pines.

Prognosis

Additional defoliation over the next few years will result in increased top-kill and mortality to white fir and Douglas-fir, particularly in the seedling-, sapling-, and pole-size classes. Dwarf mistletoe impacts on ponderosa pine will increase in severity over time.

Recommendations

A regeneration cut is recommended since white fir is a major component of every size class. Either a clearcut and plant with ponderosa pine and Douglas-fir, or a seed-tree cut using ponderosa pine and Douglas-fir as seed trees, or a combination should be performed. Only dwarf mistletoe-free trees should be left as a seed source. Oak should also be removed to favor pine and Douglas-fir regeneration.

STAND 131.1-21

Current Conditions

Douglas-fir is a minor component of the stand; 1 percent of the trees and 6 percent of the basal area. Most of the Douglas-fir is pole size; the remainder is sawtimber. Budworm damage, at this time, is primarily light to moderate defoliation. Dwarf mistletoe is extremely rare.

White fir is the predominate tree species; 54 percent of the trees and 52 percent of the basal area. If oak is excluded, white fir is 79 percent of the trees. Budworm damages to white fir are severe. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (9-4.9")	11	33	33
Poles (5-8.9")	39	56	5
Small sawtimber (9-11.9")	33	67	0
Sawtimber (12"+)	43	50	0

One root rot center was detected.

Other species include: Blackjack pine, 10 percent of the trees and 17 percent of the basal area; yellow pine, 1 percent of the trees and 20 percent of the basal area; juniper, 3 percent of the trees and 1 percent of the basal area; and oak, 32 percent of the trees and 4 percent of the basal area. The oak is brush; 99 percent is less than 5 inches in diameter.

Dwarf mistletoe is present on both yellow and blackjack ponderosa pine. No infested yellow pine trees were in the plots, but they were observed. Thirteen percent of the blackjack pines tallied were infected with dwarf mistletoe.

Prognosis

White fir is already heavily impacted by the budworm. The majority of white fir is in seedling-, sapling-, and pole-size classes. These size classes will be further damaged, rendering them worthless for the next stand. Poles and small sawtimber will have defects from top-kill. Dwarf mistletoe on pine may intensify as a result of the upcoming sale if precautions are not taken.

Recommendations

White fir should be salvaged along severely mistletoe-infected pine. Artifical regeneration and, due to the oak brush, site preparation will be necessary. Also, ponderosa pine regeneration should be thinned to proper stocking levels, selecting against dwarf mistletoe-infected trees.

STAND 131.1-23

Current Conditions

Douglas-fir is a minor component of the understory, but the second most common overstory tree species. It is 5 percent of the trees, but 26 percent of the basal area. All of the overstory trees have been defoliated, and 10 percent of the trees have top-kill.

White fir is the major tree species, 47 percent of trees and 55 percent of the basal area. If oak is not included, white fir is 83 percent of the trees. Budworm damages are already severe on white fir in this stand. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	4	48	22
Poles (5-8.9")	55	0	0
Small sawtimber (9-11.9")	47	43	0
Sawtimber (12"+)	40	32	0

Permanent tree damages have occurred to overstory white firs; approximately one-third of the trees have been top-killed. Two root rot centers were detected. The specific pathogen was not determined; however, Armillariella mellea is suspected. Fir broom rust is present, but rare.

Other trees species include: Aspen, 1 percent of the trees and 6 percent of the basal area; blackjack pine, 2 percent of the trees and 13 percent of the basal area; juniper, 2 percent of the trees, representing no basal area; and oak, 43 percent of the trees.

There are no significant pest problems on these tree species, except aspen, of which 50 percent of the sawtimber-sized trees have stem decay.

Prognosis

Permanent tree damages due to budworm will increase in severity over the next several years on both Douglas-fir and white fir. Defect and degrade due to top-kill will increase substantially on white fir. The root rot centers will slowly increase in size, causing further mortality.

Recommendations

Sanitation/salvage of budworm damaged white fir is recommended. Since the only regeneration present is budworm-damaged white fir, artifical regeneration with ponderosa pine and/or Douglas-fir is necessary. Healthy blackjack pine or Douglas-fir, where present, can be used as a seed source. White fir root rot centers should be salvaged and planted with ponderosa pine or Douglas-fir. Douglas-fir seed trees may not produce seed until the budworm outbreak collapses; conelets are a preferred food source for budworms.

STANDS 131.2-9 AND 131.2-10

Because of their similar characteristics, stands 131.2-9 and 131.2-10 were combined.

Current Conditions

Douglas-fir is a common component of the stands; 10 percent of the trees and 12 percent of the basal area. However, 80 percent of these trees are under 5 inches d.b.h. Light to moderate budworm defoliation is extensive throughout all size classes. Neither top-kill nor mortality has occurred thus far. No dwarf mistletoe infections were detected.

White fir is the major component; 76 percent of the trees and 73 percent of the basal area. Budworm-caused defoliation and top-kill have occurred in all size classes, with some mortality in trees less than 9 inches d.b.h. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	37	3	1
Poles (5-8.9")	59	31	7
Small sawtimber (9-11.9")	62	34	0
Sawtimber (12"+)	86	9	0

Other species include: Aspen, 4 percent of the trees and 8 percent of the basal area; blackjack pine, less than 1 percent of the trees and 3 percent of the basal area; juniper, 1 percent of the trees and less than 1 percent of the basal area; and oak, 9 percent of the trees and 3 percent of the basal area.

There are no significant pest problems on these species

Prognosis

This stand is highly susceptible to budworm damages. Heavy defoliation, top-kill, and some mortality has occurred. Top-kill and mortality will increase with additional defoliation. Most white fir regeneration will be lost, and advanced regeneration will not be suitable for the next stand.

Recommendation

Sanitation/salvage of these two stands, with treatment of the oak and artificial regeneration of ponderosa pine and Douglas-fir, is recommended because of budworm damages present and the preponderance of white fir.

Current Conditions

Douglas-fir is a significant component of the stand; 13 percent of the trees and 20 percent of the basal area. Light to heavy defoliation was common in all size classes. Top-kill occurred in 45 percent of all trees under 9 inches d.b.h. No dwarf mistletoe was detected within the survey plots. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	56	44	0
Poles (5-8.9")	54	46	0
Small sawtimber (9-11.9")	100	0	0
Sawtimber (12"+)	100	0	0

White fir is the major component of the stand; 51 percent of the trees and 43 percent of the basal area. Light to heavy defoliation and top-kill were prevalent in all size classes and significant mortality has occurred in trees under 5 inches d.b.h. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	53	29	18
Poles (5-8.9")	18	82	0
Small sawtimber (9-11.9")	68	32	0
Sawtimber (12"+)	79	21	0

Other species include: Aspen, less than 1 percent of the trees and 1 percent of the basal area; blackjack pine, 15 percent of the trees and 33 percent of the basal area; yellow pine, less than 1 percent of the trees and 2 percent of the basal area; and oak, 21 percent of the trees and 1 percent of the basal area.

Moderate to heavy dwarf mistletoe infections occurred in 12 percent of the blackjack pine over 5 inches d.b.h.

Prognosis

If left untouched, susceptibility to budworm will remain high as will damages to white fir and Douglas-fir. Eventually, most white fir and Douglas-fir regeneration will be lost, and the advanced regeneration will not be suitable for the next stand. Poles and sawtimber will have defects and reduced growth from top-kill and repeated defoliation.

Recommendation

Salvage of white fir, leaving nondwarf mistletoe-infected ponderosa pine and Douglas-fir as a seed source, is recommended. In some areas, artifical regeneration of ponderosa pine and Douglas-fir may be necessary. Some site preparation may also be needed to remove undesirable oak. Ponderosa pine regeneration should be thinned to proper stocking levels, selecting against dwarf mistletoe-infected trees.

STAND 131.2-13

Current Conditions

Douglas-fir is a significant component of the stand; 21 percent of the trees and 26 percent of the basal area. Light to heavy defoliation was common in all size classes. Top-kill occurred in 50 percent of the trees below 5 inches d.b.h. Dwarf mistletoe occurred in 28 percent of the trees. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	39	50	0
Poles (5-8.9")	100	0	0
Small sawtimber (9-11.9")	71	0	0
Sawtimber (12"+)	63	0	0

White fir is the major component of the stand; 47 percent of the trees and 50 percent of the basal area. Light to heavy defoliation and top-kill were prevalent in all size classes; however, no mortality has yet occurred. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	74	13	0
Poles (5-8.9")	56	39	0
Small sawtimber (9-11.9")	49	51	0
Sawtimber (12"+)	77	20	0

Other species include: Aspen, 8 percent of the trees and 7 percent of the basal area; blackjack pine, 4 percent of the trees and 11 percent of the basal area; yellow pine, less than 1 percent of the trees and 1 percent of the basal area; Engelmann spruce, less than 1 percent of the trees and 3 percent of the basal area; oak, 20 percent of the trees (all under 5 inches d.b.h.) and 1 percent of the basal area.

No pest problems were detected in these species.

Prognosis

Further defoliation will cause additional top-kill and mortality, particularly in the smaller size classes of white fir and Douglas-fir. Eventually, most white fir and Douglas-fir regeneration will be lost, advanced regeneration will not be suitable for the next stand, and sawtimber will suffer growth loss, degradation, and deformity.

Recommendation

Due to the high percentage of damaged white fir in the stand, we recommend the stand be salvaged. Nondwarf mistletoe-infected ponderosa pine and Douglas-fir leave trees may serve as a seed source, where possible. Artifical regeneration may also be necessary. Site preparation to remove oak will be necessary for both alternatives.

Current Conditions

Douglas-fir is a minor component of the stand; 4 percent of the trees and 1 percent of the basal area (99 percent of the Douglas-fir are under 5 inches d.b.h.). Budworm defoliation is light in the few overstory trees; however, damages to the understory are severe. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	25	25	50
Poles (5-8.9")	0	0	0
Small sawtimber (9-11.9")	•	0	0
Sawtimber (12"+)	100 (0.6 trees/acre with light defoliation)	0	0

No dwarf mistletoe infections were detected in Douglas-fir.

White fir is the most common species within the stand; 51 percent of the trees, representing 57 percent of the basal area. Moderate to heavy defoliation and top-kill are prevalent in all size classes, and mortality has occurred in 11 percent of all white fir under 12 inches d.b.h. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and saplings (0-4.9")	59	20	11
Poles (5-8.9")	47	36	14
Small sawtimber (9-11.9")	31	59	11
Sawtimber (12"+)	37	63	0

Shoestring root rot, Armillariella mellea, was found on 2 percent of the Douglas-fir.

Other species included: Aspen, 7 percent of the trees and 2 percent of the basal area; blackjack pine, 14 percent of the trees and 22 percent of the basal area; yellow pine, less than 1 percent of the trees and 11 percent of the basal area; and oak, 23 percent of the trees and 6 percent of the basal area.

Dwarf mistletoe infections are common in blackjack pine; 42 percent of all blackjack pine under 9 inches d.b.h. are infected.

Prognosis

Further defoliation will increase the amount of top-kill and mortality in white fir and Douglas-fir and severely decrease the value of the present stand. Most white fir and Douglas-fir regeneration will be lost, and advanced regeneration will not be suitable for the next stand. If left uncontrolled or mismanaged, blackjack dwarf mistletoe infections will spread, thus reducing growth and value of the blackjack component.

Recommendation

Since the major component of the stand (white fir) is already severely damaged, with further damages expected, we recommend sanitation/salvage followed by removal of oak and artificial regeneration of ponderosa pine and Douglas-fir.

STANDS 131.2-15 AND 131.2-16

Current Conditions

On the upper elevations of these stands, nearly all the white fir is dead, or will be within a year or two. There is no regeneration present that is usable. The lower elevations, especially on stand 16, have had little defoliation at all. There is good ponderosa pine, Douglas-fir, and white fir regeneration present.

Douglas-fir is a major component of the stand; 16 percent of the trees and 32 percent of the basal area. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and Saplings (0-4.9")	0	43	0
Poles (5-8.9")	40	43	0
Small sawtimber (9-11.9")	55	28	0
Sawtimber (12"+)	74	19	0

Permanent tree damages are occurring, but no mortality has occurred yet. Dwarf mistletoe infections are severe and extensive; 17 percent of the pole-sized trees, 28 percent of the small sawtimber, and 40 percent of the sawtimber are infected.

White fir is the most common tree species in the stand, 52 percent of the trees and 35 percent of the basal area. Budworm impacts are as follows:

	Percent of trees with --		
	Defoliation	Top-kill	Mortality
Seedlings and Saplings (0-4.9")	22	37	19
Poles (5-8.9")	24	15	60
Small sawtimber (9-11.9")	34	32	33
Sawtimber (12"+)	29	55	15

Permanent tree damages are severe; 35 percent of all the trees have top-kill and 23 percent of all the trees are dead. Fir broom rust is present, but rare.

Other tree species include: Aspen, 9 percent of the trees and basal area; blackjack pine, 6 percent of the trees and 22 percent of the basal area; yellow pine, less than 1 percent of the trees and 1 percent of the basal area; and oak, 18 percent of the trees and less than 1 percent of the basal area.

Some of the aspen has stem decay. Most of the blackjack pines, 72 percent, are infected with dwarf mistletoe, with 100 percent of the regeneration infected.

Prognosis

Budworm-caused mortality of Douglas-fir will start within a year or two. The amount of white fir mortality due to the budworm will increase dramatically in the next several years. Most of the white fir classified as top-killed appeared to be just barely alive and are not expected to survive the outbreak. Within 5 years, the stand is expected to be understocked with nonhost trees and oak brush. Dwarf mistletoe infections on Douglas-fir and ponderosa pine will intensify with time.

Recommendations

The stand should be salvaged, the oak brush treated, and ponderosa pine and/or Douglas-fir should be planted. Most of the host-tree regeneration is already damaged and the ponderosa pine regeneration is sparse and heavily infected with dwarf mistletoe. Stand 16, along road 171, may have advanced regeneration that is acceptable for an overstory removal cut. This area should be inspected to see if this can be done.